WATER QUALITY CONTROL
IN SASKATCHEWAN

The term "water quality" can include subjects related to the chemical, biological and physical sciences and sociological, economic and philosophical aspects. "Water quality control" alludes to political, legal and/or physcial implications. Restricting the topic to a geographical area assists definition to some extent. The intent of the following is to present a brief overview of the Commission's water quality management program and examine some of the existing problems of water quality and its control.

1. WATER QUALITY MANAGEMENT PROGRAM

A. Policy

The general philosophy behind the policy is that the water quality management program should protect and enhance the capacity of the province's water resource to serve the widest possible range of uses in the most efficient manner. The basic objectives, finalized after public hearings in 1967, are to conserve water and to protect, maintain and improve its quality for the protection of public health and, within economic limits for the following purposes:

(a) preservation and protection of water supplies;

(b) encouragement of economic development;

(c) preservation of aesthetic values; and

(d) preservation of fish and wildlife.

With respect to waste discharges the policy decreed that there should be a minimum of primary treatment for all municipal and industrial wastewaters and that the discharge of suitably treated wastewater to surface waters was permissible provided such discharge did not impair water quality to the extent that it adversely and unreasonably affected its use. Thus the avenue of "pollution control" rather than "non-pollution" was adopted.

B. Legislation

The Water Resources Commission Act provides the Saskatchewan Water Resources Commission with the general supervision, control and regulation of all matters concerning waterworks, sewage works, water quality and its impairment by pollution(1). The Act also states that the discharge of polluting substances is prohibited unless authorized. New sections passed in 1971 permit an order of cessation and an order to clean up materials or substances deposited without approval.

The Water Pollution Control Regulations pertain mainly to approvals of construction and operation of municipal, large private and industrial works but also includes an approval requirement for herbicide applications to public waters.

The Commission program is achieved mainly through the issuance of approvals to operate wastewater works. These approvals are issued on the basis of quality requirements, where feasible, and for specific terms that do not exceed five years.

Important ancillary legislation includes "The Pollution Prevention Regulations for the Mineral Industry, 1970," administered by the Department of Mineral Resources to control the discharge of mining wastes into the environment and "The Pollution (by Livestock) Control Act, 1971," through which intensive livestock operations are controlled by the Department of Agriculture. (2)(3) Both pieces of legislation require that prior approval for each case be given by environmentally oriented agencies such as the Commission.

C. Water Quality Objectives

The Commission has not felt it desirable to establish rigid effluent or receiving water quality standards nor to classify streams. Each case of water quality impairment or waste discharge is examined individually. However, basic objectives have been stated in the context that municipal, industrial, agricultural or other discharges should be:

(a) free from substances in concentrations or combinations which are toxic or may be harmful to human, animal or aquatic life;

(b) free from substances that will settle to form putrescent or otherwise objectionable sludge deposits, or that will adversely affect aquatic life or waterfowl;

(c) free from debris, oil, grease, scum or other materials in amounts sufficient to be noticeable in the receiving water;

(d) free from colour, turbidity or odour-producing materials that would:

(i) adversely affect aquatic life or waterfowl;

(ii) significantly alter the natural colour of the receiving water;

(iii) directly or through interaction among themselves or with chemicals used in water treatment, result in undesirable taste or odour in treated water;

(e) free from nutrients in concentrations that create nuisance growths of aquatic weeds or algae in the receiving water.

The specific effluent requirements are based on the receiving stream and the water quality criteria.

In 1968, the Commission's first set of water quality criteria or objectives was published. The surface water values were divided into user categories and resulted from literature observations, review of provincial quality data, and many comments from interested agencies, organization and individuals. Through the prairie provinces Ministers of Health and the Canadian Council of Resource Ministers, the three prairie provinces commenced preparation of common surface water quality objectives in order to avoid creation of "pollution havens" and to demonstrate co-operation and forestall implementation of The Canada Water Act. In early 1970, agreement was reached and both Saskatchewan and Alberta published the common objectives shortly thereafter. (4)(5) Manitoba has yet to officially adopt the criteria but, in fact, use them as guidelines.(6) Aside from parameter modifications and concentration revisions one major change was the concept of a 'universal user'. In actual practice the Commission had applied the most critical values for each constituent, regardless of user. It should be noted that it is intended to periodically review and revise, if necessary, the complete set of surface water quality objectives.

The specific constituent objectives for surface water, presented in Table 1, must be considered in light of the following:

(a) They represent water quality suitable for most uses either through direct use or prepared for use through an economically practical degree of treatment.

(b) The objectives do not apply to prescribed areas in close proximity to outfalls.

(c) Naturally occurring circumstances such as runoff effects on turbidity and colour are not taken into account.

(d) The values are to be considered basic objectives and more stringent objectives may be required because of specific uses.

(e) There are many instances where natural existing quality is inferior to the suggested limits. In these cases it is considered unwise to permit further deterioration by unlimited or uncontrolled introduction of pollutants.

(f) Where natural quality is far superior to the objectives as in some northern lakes special attention will be given to preserve that quality.

For certain parameters the objectives are expressed in terms of increases over natural or background values which implies their application to effluent discharges. The determination by the Commission of permissive waste discharges to a receiving water body is guided by use of the objectives. However, no one should interpret the criteria to mean that the stated values are in effect a licence to pollute to that limit.

TABLE 1

SURFACE WATER QUALITY CRITERIA

These criteria have been prepared in co-operation with the Provinces of Alberta and Manitoba and represent water quality suitable for most uses either through direct use or prepared for use by an economically practical degree of treatment.

Parameter	Criteria
1. Bacteriology (Coliform Group)	(a) In waters to be withdrawn for treatment and distribution as a potable supply or used for outdoor recreation other than direct contact, at least 90 per cent of the samples (not less than five samples in any consecutive 30-day period) should have a total coliform density of less than 5,000 per 100 ml and a fecal coliform density of less than 1,000 per 100 ml. (The Maximum Permissible Limit of total coliform organisms in a single sample shall be determined by the Commission based on the type and degree of pollution and other local conditions existing within the watershed.) (b) In waters used for direct contact recreation or vegetable crop irrigation the geometric mean of not less than five samples taken over not more than a 30-day period should not exceed 1,000 per 100 ml total coliforms, nor 200 per 100 ml fecal coliforms, nor exceed these numbers in more than 20 per cent of the samples examined during any month, nor exceed 2,400 per 100 ml total coliforms on any day.
2. Dissolved Oxygen	A minimum of five mg/1 at any time.
3. Biochemical Oxygen Demand	Dependent on the assimilative capacity of the receiving water. The BOD must not exceed a limit which would create a dissolved oxygen content of less than five mg/1.
4. Suspended Solids	Not to be increased by more than 10 mg/1 over background value.
5. pH	To be in the range of 6.5 to 8.5 pH units but not altered by more than 0.5 pH units from background value.
6. Temperature	Not to be increased by more than 3°C above ambient water temperature.
7. Odour	The cold (20°C) threshold odour number not to exceed eight.
8. Colour	Not to be increased more than 30 colour units above natural value.
9. Turbidity	Not to exceed more than 25 Jackson units over natural turbidity.

10. Organic Chemicals

Constituent	Maximum Concentration (mg/1)
Carbon Chloroform Extract (CCE) (includes Carbon Alcohol Extract)	0.2
Methyl Mercaptan	0.05
Methylene Blue Active Substances	0.5
Oil and Grease	— substantially absent no irridescent sheen
Phenolics	0.005
Resin Acids	0.1

continued

Table 1 — continued

Pesticides

To provide reasonably safe concentrations of these materials in receiving waters an application shall not exceed 1/100 of the 48-hour Tl_m. Persistent insecticides such as DDT, Aldrin, Dieldrin, Endrin, Heptachlor should not be used on or near surface waters.

11. Inorganic Chemicals

Constituent	Maximum Concentration (mg/1)
Boron	0.5
Copper	0.02
Fluoride	1.5
Iron	0.3
Manganese	0.05
*Nitrogen (Total Inorganic and Organic)	1.0
*Phosphorus as PO_4 (Total Inorganic and Organic)	0.15
Sodium (as per cent of cations)	between 30 and 75
Sulphide	0.05
Zinc	0.05

* These criteria are presently under study and may require adjusting according to naturally occurring concentrations or conditions.

NOTE: The predominant cations of sodium, calcium and magnesium and anions of sulphate, chloride and bicarbonate are too variable in the natural water quality state to attempt to define limits. Nevertheless, in order to prevent impairment of water quality, where effluents containing these ions are discharged to a water body the permissible concentration will be determined by the Commission in accordance with existing quality and use.

12. Toxic Chemicals

Constituent	Maximum Concentration (mg/1)
Arsenic	0.01
Barium	1.0
Cadmium	0.01
Chromium	0.05
Cyanide	0.01
Lead	0.05
Mercury	0.0001
Selenium	0.01
Silver	0.05

13. Radioactivity

Gross Beta not to exceed 1,000 pCi/1.
Radium 226 not to exceed three pCi/1.
Strontium 90 not to exceed 10 pCi/1.

14. Unspecified Substances

Substances not specified herein should not exceed values which are considered to be deleterious for the most critical use as established by the Commission.

D. Water Quality Surveillance

Inherent in any water quality management program is the need to monitor stream, lake and effluent quality throughout the year. At present the Commission has 118 water quality stations that are monitored in varying frequencies depending upon the location or problem and the season of the year. Much of the Commission's emphasis has been directed towards effluents and the effects of their discharge on the receiving stream although other studies have been carried out. Substantially augmenting the monitoring program are the networks established by Environment Canada. They now operate 113 stations although some coincide with the provincial locations. An indication of the extent of routine monitoring in the province is shown on Figure 1. Many of these surveillance points have only come into operation in the last few years.

The increasing awareness of and effort related to water pollution control in this province is reflected by a comparison of the 1969 sampling program to the 1971 program. For example, the number of samples collected and/or requested by the Water Pollution Control Branch for analyses by the Provincial Laboratories increased from some 350 in 1969 to 1,250 in 1971. During the same period the average number of parameters assayed per sample has grown from 8.5 to 12.5 which reflects improved analytical techniques and the need for more thorough examinations. These figures do not consider contract work or analyses conducted in other laboratories. Monthly trends are shown on Figure 2.

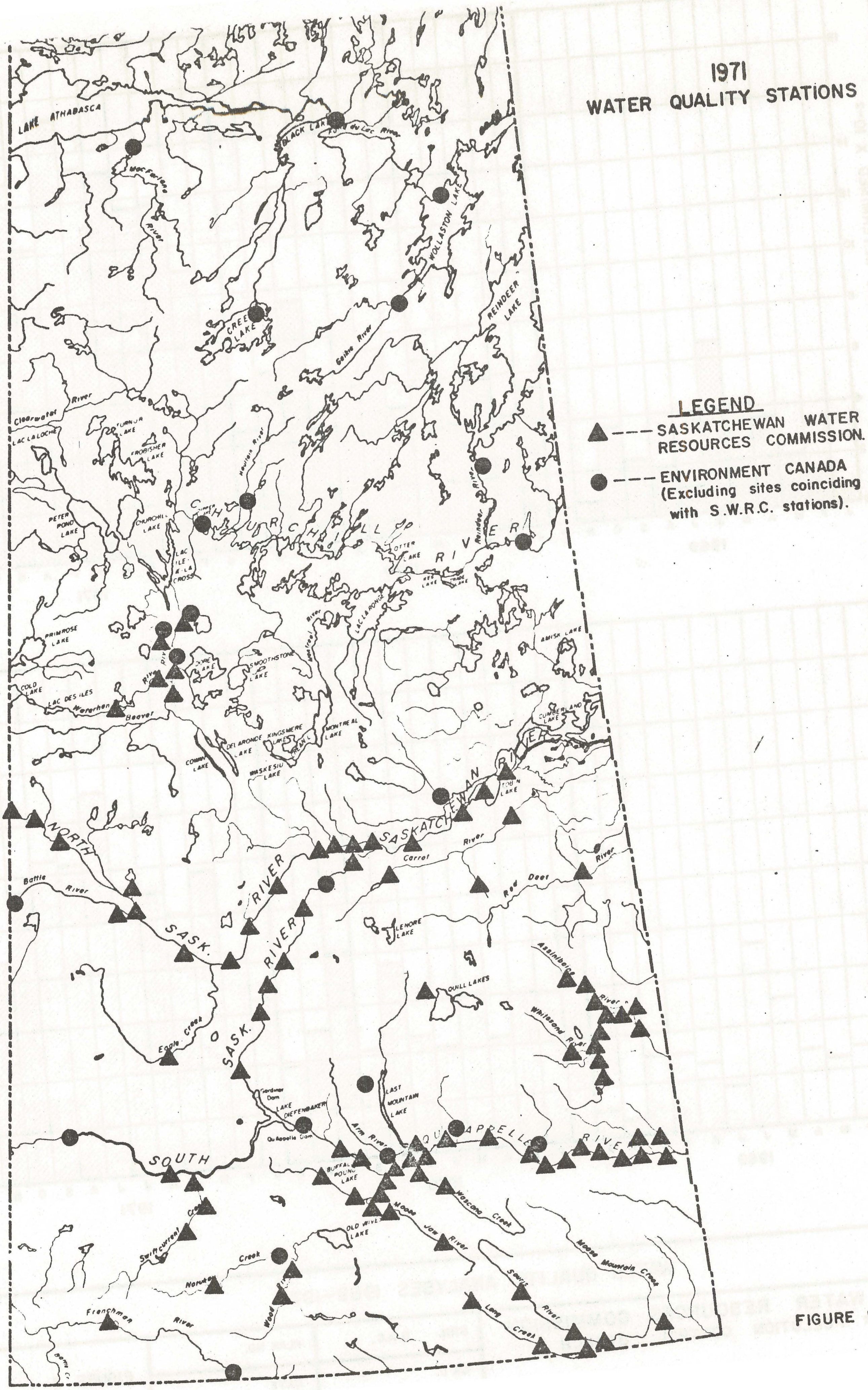
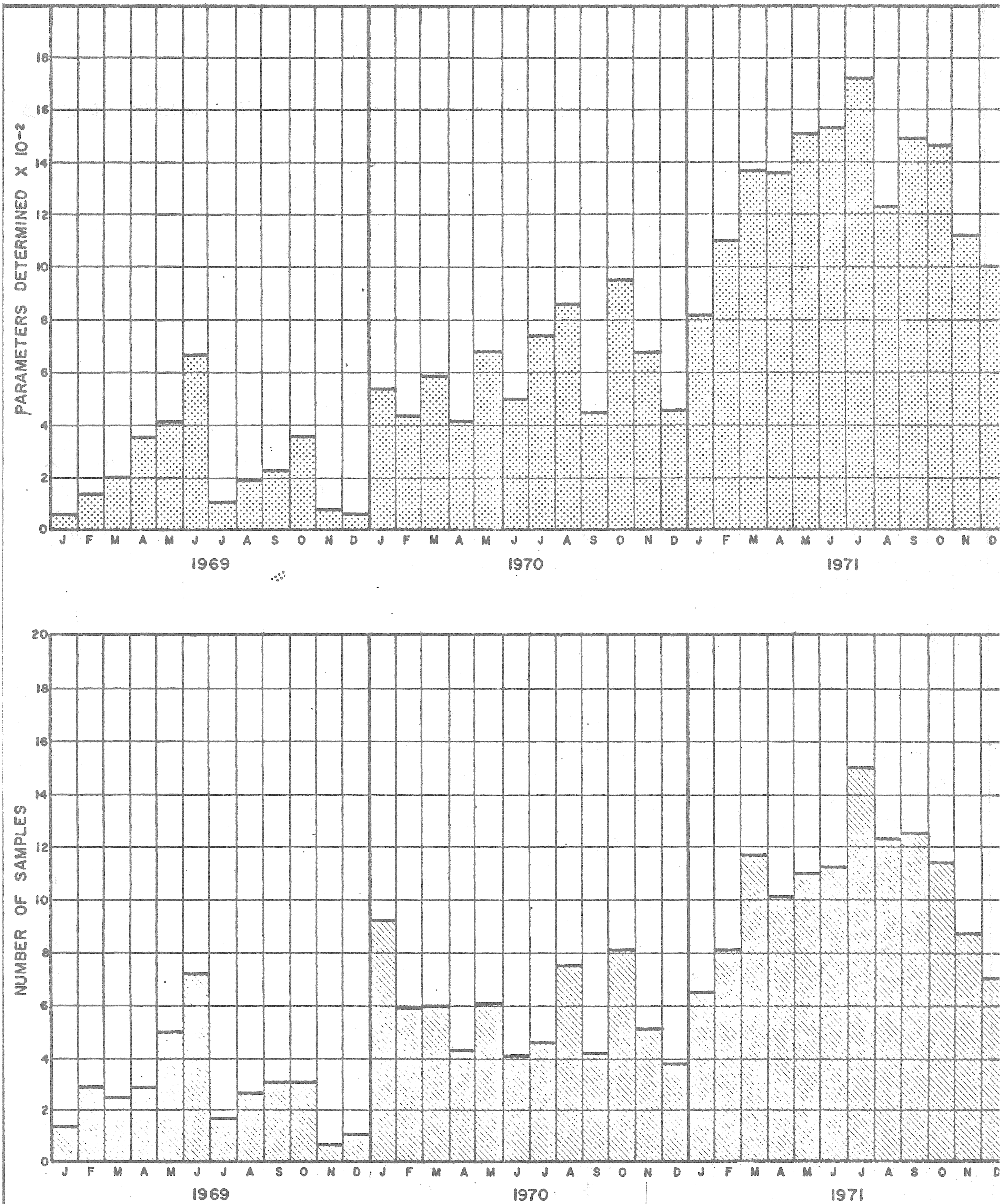

1971
WATER QUALITY STATIONS
LEGEND
SASKATCHEWAN WATER RESOURCES COMMISSION.
ENVIRONMENT CANADA (Excluding sites coinciding with S.W.R.C. stations).
LAKE ATHABASCA
BLACK LAKE
Fond du Lac River
MacFarlane River
WOLLASTON LAKE
CREE LAKE
Geikie River
REINDEER LAKE
Clearwater River
LAC LA LOCHE
TURNOR LAKE
FROBISHER LAKE
PETER POND LAKE
CHURCHILL LAKE
LAC ILE-A-LA CROSSE
CHURCHILL RIVER
OTTER LAKE
Reindeer River
LAC LA RONGE
PRIMROSE LAKE
SMOOTHSTONE LAKE
AMISK LAKE
COLD LAKE
LAC DES ILES
Waterhen
Beaver River
DELARONDE LAKE
KINGSMERE LAKE
MONTREAL LAKE
COWAN LAKE
WASKESIU LAKE
CUMBERLAND LAKE
SASKATCHEWAN RIVER
TOBIN LAKE
NORTH SASK. RIVER
Battle River
Carrot River
Red Deer River
LENORE LAKE
SOUTH SASK. RIVER
QUILL LAKES
Assiniboine River
Whitesand River
Eagle Creek
Gardiner Dam
LAKE DIEFENBAKER
LAST MOUNTAIN LAKE
Qu'Appelle Dam
Arm River
QU'APPELLE RIVER
BUFFALO POUND LAKE
Wascana Creek
Moose Jaw River
OLD WIVES LAKE
Swiftcurrent Creek
Notukeu Creek
Moose Mountain Creek
Souris River
Long Creek
Wood River
Frenchman River
Battle Cr.

FIGURE I



WATER QUALITY ANALYSES 1969–1971

SASK. WATER RESOURCES COMMISSION WATER POLLUTION CONTROL BRANCH	DRN. D.A.C.	PLAN NO.	FIGURE 2
	CK'D.	DATE	

Water quality data input is also generated by other agencies and persons. Of particular note are the limnology and fisheries reports by the Department of Natural Resources. They also have assisted the Commission in surveillance work. The Saskatchewan Research Council documented surface water quality in a 1970 publication (7). Other studies conducted by university staff and students have increased the available data. The Qu'Appelle Basin Study involved the collection of many hundreds of samples. One of the problems yet to be resolved is the meaningful correlation and integration of data.

2. SOME WATER QUALITY AND CONTROL PROBLEMS

Legislation has provided authority over the discharge of sanitary sewage, industrial effluents and other forms of wastes that are amenable in a practical sense to control. Although there are economic ramifications, technology is available to have a piped effluent at any desired quality. Some water quality and control problems not so easily resolved include those related to natural quality, ground water, conflict of use and multiple use water systems, the lack of adequate receiving waters, and the eutrophication question.

A. Background Quality and Data

Many of Saskatchewan's water bodies suffer from some deficiency with respect to quality because of natural or background conditions. The saline lakes and many of the small isolated southern lakes having profuse aquatic vegetation growths are examples. The influence of insitu soil and mineral leaching on quality seems quite apparent in the case of the Saskatoon-Southeast Water Supply System. Samples collected during the summer, 1971, survey revealed conductivity increased from 370 μmho/cm in the upper end above Broderick Reservoir to 970 μmho/cm in the south portion of Blackstrap Reservoir to 1,270 μmho/cm in the north end of Blackstrap. (8)

Even the northern waters, where man's activities are negligible, are susceptible to quality impairment. In the upper Churchill River system the Beaver River was found to have extremely low dissolved oxygen contents during the late winter period. The cause has been postulated to be due to significant inflows of oxygenless ground water and muskeg drainage containing low oxygen levels. Waters of this quality render the siting of wet industries a costly venture since an exceptionally high degree of wastewater treatment is required with the low assimilative capacities available in the surface streams.

Problems have occurred as a result of activities beyond the provincial borders. The winter quality of the North Saskatchewan River is a prime case in point. Serious problems were encountered about 1954 when the discharge of partially treated sewage from Edmonton and industrial effluents from the Edmonton area resulted in taste and odour problems and a severe dissolved oxygen depletion. This problem persisted for several years, and for three winters, the river became devoid of oxygen in Saskatchewan from December until breakup. Requirements for better treatment by Alberta authorities has eased the situation but the quality is still minimal. For example during January and February, 1971, the DO content at the border dropped to the 5.5 to 6.0 mg/l range. Due to the lack of reaeration the oxygen consumption continued such that levels of 3 to 4 mg/l were obtained at Prince Albert. Referring back to the criteria it can be readily noted that this quality provides little assimilative capacity for Saskatchewan wastes. Further improvements are expected in the near future.

The lack of adequate background water quality data hampers control in the sense that quality trends and long-term effects of past practices are unknown. It must be acknowledged that the early works of the provincial fisheries personnel and the federal Department of Mines and Technical Resources are valuable references but many lack data on constituents presently of concern. For example, it would be most enlightning, in view of the current mercury problem, to have information on the levels of this metal in fish and water at some time in the past. In this context we can only wonder how deficient our data and methodology will be considered in future years.

B. Ground Water

Ground water is an important resource in this province which is reflected in the fact that 294 out of the 378 communities with a municipal waterworks utilize it as the sole source of water supply. Unfortunately, ground water may suffer from high salinity or dissolved solids contents which deters its use for municipal, industrial or irrigation purposes. However, faced with no economical alternative, many communities are forced to accept water of inferior quality. Thirty-five per cent or 104 of the centres utilizing ground water have water quality with a dissolved solids content in excess of 1,500 mg/1, the maximum recommended limit. It is hoped that the abundant research on demineralization techniques will soon result in practical and economical applications of this treatment method in this province.

The interchange of ground and surface waters can have a significant impact on water quality. Currently the Commission is carrying out studies to determine the quality effects of large aquifers intersecting streams.

C. Conflict of Use

It seems inherent that endeavouring to satisfy a wide range of water users a conflict of interest will result which requires careful resolution.

A lake that has been given rather intensive consideration and attention in the last few years is Buffalo Pound which serves as a water supply for the Cities of Regina and Moose Jaw. Buffalo Pound Lake gained prominence in the early months of 1967 when a massive fish kill resulted from the loss of oxygen in the lake. The shallow, mud-bottomed lake had been resurrected from the status of a large slough in 1940 and its capacity subsequently increased. The lake, primarily subject to agricultural runoff and water importation from the South Saskatchewan River, has been very productive and, during the summer, supports massive blooms of blue-green algae (9) (10). The temporary cessation of water importation due to Lake Diefenbaker filling during 1966 left the lake stagnant and a late algal bloom persisted until ice formation. This fresh crop of organic material is believed to have accelerated the oxygen depletion. (11)

The fish kill stimulated the need to import water for maintenance of water quality as well as consumptive purposes. As a result for the following winter the lake was surcharged and winter inflow — outflow initiated. This practice was carried on at decreasing rates for the following two winters. However, since water from Lake Diefenbaker has a power generation value, since lake surcharging was causing bank erosion, and since difficulties were encountered downstream as a result of the fairly large outflows it was deemed desirable to minimize importation and stabilize lake levels as much as possible.

Winter water quality monitoring was undertaken to gauge the effect of the winter operation and to attempt to arrive at an optimum operating procedure. Based on this data a program was designed which has been followed over the past two years. Figure 3 illustrates the trends of dissolved oxygen at a selected point in the lake from 1968 to 1972. It is anticipated that the best compromise may have been reached.

A rather straightforward conflict of use is illustrated by the case of Macklin Lake. Set in very pleasant surroundings the small lake was virtually created by the construction of a dam in the late 1930's and the project was designated for domestic and stockwatering purposes. A substantial number of cattle

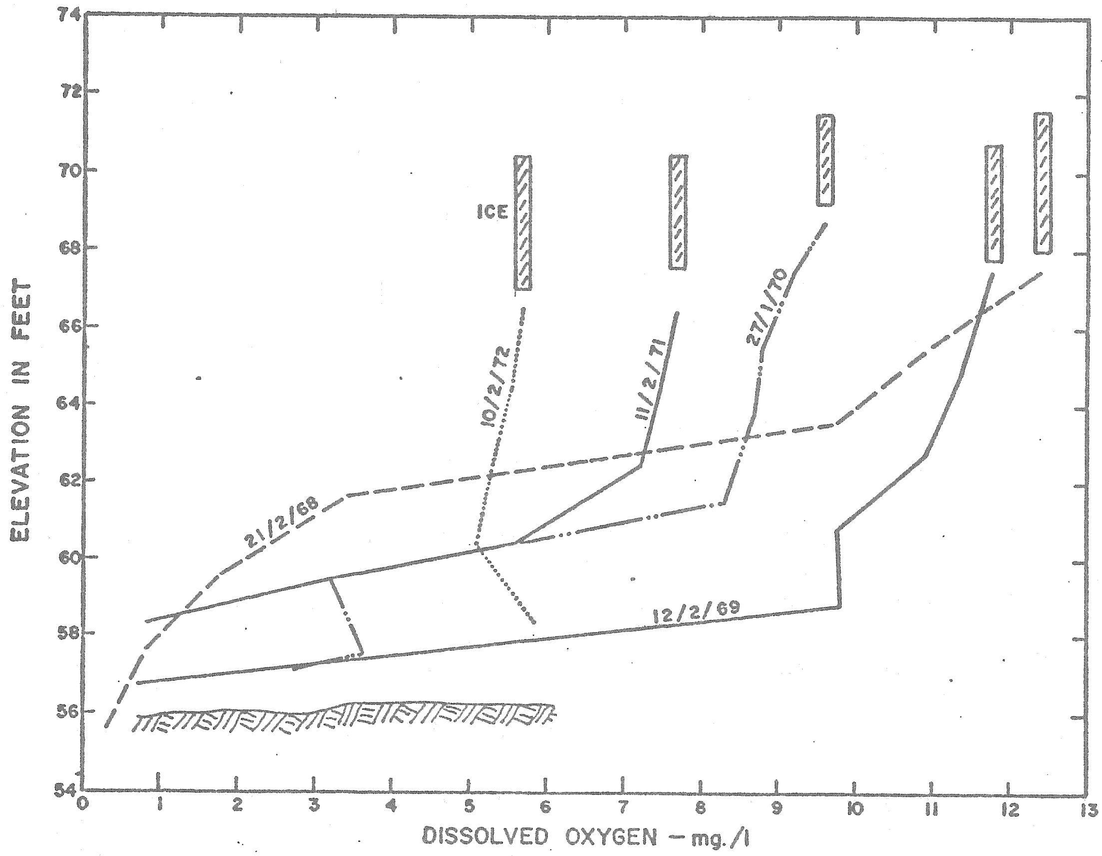


Figure 3 WINTER DISSOLVED OXYGEN TRENDS
BUFFALO POUND LAKE — STATION B-7

abide by the lake and one owner kept a number of head in confined quarters adjacent to the lake. In recent years a regional park was established, and, with the natural sand, a bathing beach prepared. Shortly afterwards concern was expressed about the nuisance blooms of algae and the possibility of pollution from the cattle. An investigation revealed that: The lake was enriched, extensive sludge deposits existed near the cattle area, and a pronounced bloom of Aphanizomenon extended into the beach area. No solution has been found to date.

D. Lack of Receiving Water

Due to the lack of adequate receiving waters many of the 372 communities which have communal sewerage systems have to discharge their treated effluent into intermittent creeks or runs or into poorly defined drainage courses. Although most of these works utilize lagoons which are supposed to be discharged during the spring or in the fall after harvest, serious problems arise because of flooding and/or the refusal of the landowner to permit the release of effluent onto his land. This has forced some municipalities to construct extra capacity in an attempt to maximize evaporative losses or construct costly drainage structures to bypass problem areas.

In essence, a problem of liquid disposal arises. One possible remedy would seem to be the institution of some type of irrigation. However, this liquid, while low in bacteriological population and organically well stabilized, frequently is high in dissolved salts (>2,000 mg/1) due in part to the nature of the water supply and the additions through sewage. Irrigation with effluent in this province has had limited investigation. In one instance studies suggested that irrigation on heavy land would necessitate the succession from cereal crops to grasses within five years. In two other cases the heavy clay soils ruled out this alternative. However, it may be feasible to utilize forage crops and nurseries for effluent irrigation. The results of alfalfa irrigation at Balgonie apparently are not discouraging (12). Regina has applied lagoon liquid to a nursery adjacent to the facility for some years with good success even though the soil is heavy clay and liquid has a mineral content in the 1,500 to 2,000 mg/1 range (13). The Penn State studies on wastewater renovation and conservation have shown sewage effluent irrigation of crops and forests is quite feasible (14).

It is apparent studies in Saskatchewan are required. The Commission would encourage activities or studies respecting use of treated sewage effluents.

E. Eutrophication

Eutrophication, in the sense of excessive aquatic growth production to the point of nuisance conditions, is one problem of which the public is becoming very conscious. While the focal point of the problem is generally the adverse recreational and aesthetic effects other areas affected include taste, odour and turbidity problems with water supplies, the potential detriment to aquatic biota, and the occasional toxic capabilities of certain algal species to animals.

Although some of the northern lakes, particularly those with ooze-type bottoms, are classed as eutrophic (15) (16), southern water bodies command more publicity. Perhaps the most notorious are the lakes in the Qu'Appelle River system which have considerable recreational use. These lakes, generally producing noxious blue-green algal blooms during the warm summer months, have been extensively studied to examine controlling factors and possible means of control (10).

The Qu'Appelle Basin Study, organized on an intergovernmental basis among Canada, Saskatchewan and Manitoba concludes in March, 1972. With respect to the water quality portion, one of the major work items was to prepare a nutrient budget for the basin and for individual areas. For the purposes of the budget, nutrients included the popular parameters of nitrogen, phosphate and carbon. Water quality and hydrometric stations were sited to measure contributions from municipal, rural and other sources during the April 1, 1970 to March31, 1971, sampling period.

Although reports have not yet been published a preliminary examination of the data is most interesting. With respect to runoff it was found the input of nitrogen and phosphate varied directly as the flow and the concentrations of these constituents were highest in the early part of the snowmelt. Selected basins with little or no municipal contributions revealed differing nitrogen and phosphate loads as noted in Table 2.

Table 2

PRELIMINARY DATA
SURFACE RUNOFF FROM SELECTED BASINS
(After Qu'Appelle Basin Study Board)

Basin	Nitrogen Load (lbs./contr. sq. mile)	Phosphate Load (lbs./contr. sq. mile)	Runoff Recurrenc[e] Interval, years
Upper Moose Jaw River	696	507	15
	540	389	17
Thunder Creek	78	36	12
	114	65	5
Upper Wascana Creek	191	127	6
	595	321	17
Pheasant Creek	202	136	>2
	220	120	3

Soil characteristics, land use and agricultural practices for these basins have not been correlated with the nutrient loads.

Calculation of the nutrient data on a twelve month average basis and including municipal contributions yields the following partial inputs in Table 3.

Table 3

PRELIMINARY DATA
AVERAGE YEARLY NUTRIENT INPUTS
(After Qu'Appelle Basin Study Board)

	Nitrogen pounds	Phosphate pounds
Agricultural Input		
Upper Qu'Appelle River	101,000	35,000
Moose Jaw River	175,000	125,000
Wascana Creek	85,000	60,000
Municipal Input		
Regina (1970-71)	1,540,000	1,250,000
Moose Jaw (1970-71)	340,000	280,000

It is apparent that the municipal input greatly exceeds the agricultural antecedent contribution on an average year. However, if the high runoff years as observed in the study were used for the Moose Jaw River and Wascana Creek, the agricultural inputs jump to 780,000 pounds and 568,000 pounds of N and PO_4 respectively on the Moose Jaw River and 440,000 pounds and 320,000 pounds of N and PO_4 respectively on Wascana Creek.

With respect to the entire Qu'Appelle Basin the Cities of Regina and Moose Jaw would contribute 52 per cent and 12 per cent respectively of the nitrogen and phosphate.

The annual input load of total phosphorus/unit area in terms of mean depth has been used to describe lakes of various trophic levels. (17) For a lake of five metres depth the permissible P loading is considered to be up to 0.07 g/m^2 year and the dangerous loading is in excess of 0.13 g P/m^2 year. Applying this approach to Pasqua Lake (averaging 5.9 metres in depth) the levels of phosphate input for permissible and dangerous loading would be 9,800 pounds per year and 18,200 pounds per year respectively. For Buffalo Pound Lake the figures would be 14,000 pounds PO_4 per year and 26,000 pounds PO_4 per year for the respective permissible and dangerous levels.

Inspection of nutrient inputs for the agricultural sector from the upper Qu'Appelle River and either Wascana Creek of Moose Jaw River suggest these sources alone could exceed the dangerous loadings on the lakes. Of course, the municipal input far surpasses these loading figures.

When the Qu'Appelle Basin Study Board releases its report, it may recommend nutrient removal facilities for the cities as a first step to nutrient reductions as these sources are controllable. Regina and Moose Jaw have already been advised by the Commission to seek treatment for algae removal and to investigate nutrient removal. A Central Mortgage and Housing

Corporation financed pilot project studying algae and associated nutrient removal is now underway in Regina.

Should government policy reflect the recommendation of tertiary treatment for municipal contributors, other sources will have to be reduced to effect a meaningful nutrient reduction program.

With respect to agriculture, in the area of nutrient control the Commission looks toward agrologists and soil scientists to continue the pursuit of knowledge and problem resolution and provide the education needed to assist the abatement program.

Presented to:

A Symposium:
Saskatchewan Crop Production
in Relation to Pollution

University of Saskatchewan
Saskatoon, Saskatchewan
February 18, 1972

By:

R. A. McDonald, P. Eng.,
Head, Water Quality Division,
Water Pollution Control Branch,
Saskatchewan Water Resources Commission

REFERENCES

1. Province of Saskatchewan, The Water Resources Commission Act R.S.S. 1965.

2. Province of Saskatchewan, The Pollution Prevention Regulations for The Mineral Industry, 1970.

3. Province of Saskatchewan, The Pollution (by Livestock) Control Act, 1971.

4. Province of Saskatchewan, Water Quality Criteria, Water Pollution Control Branch, Saskatchewan Water Resources Commission, June, 1970.

5. Province of Alberta, Surface Water Quality Criteria, Water Pollution Control Section, Division of Environmental Health, August, 1970.

6. Kupchanko, E. E., McDonald, R. A., and Warrener, J. N., Prairie Provinces Surface Water Quality Criteria, Papers Presented at the Twenty-Third Annual Convention, Western Canada Water and Sewage Conference, October, 1971.

7. Rutherford, A. A., Water Quality Survey of Saskatchewan Surface Waters, Chemistry Division, Saskatchewan Research Council, 1970.

8. Mead, E. L., Summer Student Shoreline Survey, 1971, Department of Chemistry and Chemical Engineering, University of Saskatchewan, Saskatoon, Saskatchewan.

9. Johnson, R. P., and Koshinsky, G. D., Report on Biological Survey of Buffalo Pound Lake, 1959, Department of Natural Resources, March, 1961.

10. Hammer, U. T., An Ecological Study of Bloom Species of Blue-Green Algae in Lakes of the Qu'Appelle River System, Saskatchewan, Department of Biology, Saskatchewan Research Council, October, 1970.

11. McDonald, R. A., Winter Water Quality, Buffalo Pound Lake, 1967-1970, Water Pollution Control Branch, Saskatchewan Water Resources Commission, November, 1970.

12. Saskatchewan Department of Agriculture, personal communication.

13. Regina Department of Public Works and Engineering, personal communication.

14. Parizek, R. R., et al, Penn State Studies, Waste Water Renovation and Conservation, Administrative Committee on Research, The Pennsylvania State University, 1967.

15. Lane, C. B., The Limnology, Fisheries and Management Potential of 17 Lakes Located Along the Hanson Lake Road, 1964-66, Saskatoon Fisheries Laboratory, Saskatoon, Saskatchewan, March, 1967.

16. Rawson, D. S., Limnology and Fisheries of Five Lakes in The Upper Churchill Drainage, Saskatchewan, Fisheries Branch, Department of Natural Resources, Province of Saskatchewan, 1957.

17. Report to the International Joint Commission, Pollution of Lake Erie, Lake Ontario and the International Section of the St. Lawrence River, Vol. 1, Summary, 1969.